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Microwave Radio Relay and Coaxial Cable in the Soviet Bloc -- Plans, Progress, and Problems

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Microwave Radio Relay and Coaxial Cable in the Soviet Bloc -- Plans, Progress, and Problems

I. Introduction

In view of the strategic importance to the Soviet Bloc of mainline telecommunications facilities using microwave radio relay and coaxial cable, an over-all assessment is needed of the present status of such facilities and plans for their extension. This report, prepared by the Electronics and Telecommunications Subcommittee of the EIC, presents such an assessment of development, production, and operational deployment aspects of microwave radio relay and coaxial cable facilities and their associated multiplexing equipment. The report represents a summary of available information, a consideration of possible problems facing the Soviet Bloc in this field, and the identification of information and research gaps.

For the purposes of this report, mainline facilities include those lines using any of the following:

A. Microwave radio relay equipment having a potential capacity of one television channel and/or 24 or more telephone channels and operating at frequencies above 1,500 mc/s.

B. Coaxial cable equipment having a potential capacity of one television channel and/or 24 or more telephone channels.

C. Multiplexing equipment capable of combining 60 or more telephone channels.*

II. Research and Development

Radio relay equipment was developed by Germany for use in World War II, and since then the USSR has become aware of its advantages which include security, anti-jamming, and frequency economy. In order to increase their communications capacity, and to provide facilities for television, the USSR as well as East Germany and Hungary, has developed microwave systems of increasingly higher capacities.

The Soviets first developed the Strela M, a 24-telephone channel system operating in the 1769-1955 mc/s band, and the Strela T, a similar equipment but without telephone channelling equipment which provides one broad-band channel for television transmission over distances of about 300 km. Soon after, the Soviets developed the Strela P, more commonly called the R-60/120, from a combination of the Strela M and Strela T. Operating in the 1,600-2,000 mc/s band, the R-60/120 provides one television video channel in one direction at a time which is reversible; and one television sound channel in both directions at the same time. In addition, channelling equipment can be added to the R-60/120 to provide up to 120 telephone channels, each of which can be converted to several telegraph channels. The R-60/120 is designed for multi-channel telephone service up to 2,500 km. and television picture transmission up to 1,000 km.

The latest Soviet development in microwave equipment is the R-600 or Vesna,** designed for television and telephone transmissions up to 5,000 km. It is designed for operation in the frequency band of 3,400 to 3,900 mc/s, and provides one duplex television channel, and up to 1,200 telephone channels in its first phase of installation. Eventually a capacity of up to three duplex television channels and about 3,840 telephone channels is envisaged. Although the development of the Vesna is reported to have been completed, there is indication of continuing research and development work on certain sections or components of the Vesna aimed at refinement of the system and a resultant improvement in performance.

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* From 3 to 24, sixty word-per-minute teletype channels can be substituted for each telephone channel. Unless stated otherwise, a telephone channel is considered to be duplex.

** For the purposes of this paper, one Vesna unit is defined as one broad-band transmitter and one broadband receiver at a single installation.

The need for wide-band multiple-channel communications systems has stimulated Soviet interest in waveguides for long-distance communication links. As early as 1950, the USSR started research on waveguide systems. Laboratory experimentation in 1956-57 prepared for the development of a waveguide system for inter-city service. An installation between Moscow and Gorkiy, a distance of approximately 300 kilometers, was planned. In close association with these practical applications, theoretical investigations and basic research are continuing.

The Soviets will probably expand their basic research and experimentation on waveguide systems in the next few years. They are aware of the desirable security features as well as the capability of handling extremely high bandwidths, that is, in the order of 1,000 megacycles per second. Such a capacity is not offered by existing communication mediums.

Efforts to extend the usable portion of the electromagnetic spectrum for use in communications may result in a technological advance in this field. Soviet work in the millimeter and submillimeter wave regions is believed to be in the research rather than in a developmental level at this time. Use of these higher frequencies for communications would result in great increases in usable bandwidth.

For use with the R-60/120 system, the Soviets have developed the KRR 30/60 and the K-60 frequency-division multiplexing equipment, which permit the simultaneous handling of up to 60 telephone channels. For the higher-capacity Vesna system, Soviet multiplexing systems K-600*, K-900, and K-1920 are under development to handle multichannel telephone signals. In order to utilize the Vesna equipment to its fullest capacity for telephone service, high-capacity multiplexing equipment is essential. Although technological problems are inherent in the development of complex electronic equipment, the Soviets have delayed in the development of this equipment longer than would normally be expected. The excessive delay probably is a matter of priority. The Soviets are known to have given preference to the development of equipment for military purposes. For example, for a number of years their best research and development efforts were directed to the improvement of their radar, ~~systems and equipment~~. Now that Soviet radars can compare with ~~those~~ of ~~any other country, and have been installed in large numbers~~, it is reasonable to expect that ~~the efforts of some Soviet engineers and technicians formerly directed to radar design~~ will be directed to items lower on the priority list. These may well include the Soviet microwave system, refinement of the Vesna, and its associated multiplexing equipment.

In East Germany, development of microwave equipment has continued since World War II. The East Germans have designed a variety of models designated the RVG series, the latest of which is the RVG-958, the East German counterpart of the Vesna. Both have the same design-potential channel capacity. Although the development of the RVG-958 was scheduled for completion by 1960, it probably will not be completed until 1962. This can be attributed in large measure to the shortage of technical personnel in East Germany, brought about by the high rate of defection to the West.

The development of multiplexing equipment for the RVG-958 probably will be a major problem, although such a set is reported to be under laboratory development. So far, the V-60, a 60-channel set, is the highest capacity unit under development in East Germany. Some experimental models of the V-60 have been produced ~~by the VEB Fernmeldewerk, Bautzen~~, but they have not functioned satisfactorily when tested on cable lines. This equipment was to be available for installation in 1959. Indications are, however, that availability ~~will~~ be delayed until ~~sometime~~ late in 1961.

In Hungary, beginning in the early 1950's, a series of mobile military microwave sets were designed and prototypes produced. Later, development began on the PM-24,** a 24-telephone channel fixed set designed for civilian use, which was patterned after Swiss Brown-Boveri equipment. Later refinements led to the PM-28. As a result of this experience in development and production, reports indicate an agreement was reached in 1959 between Hungary and the USSR under which Hungary, by 1963, will develop a more modern, broad-band type of microwave equipment having a capacity similar to the Vesna and the RVG-958. While reports also indicate that some of these sets, called the GTT/4000*** have been produced already, it would seem that this was accomplished from the Vesna plans and specifications handed over by the Soviets, and that these sets are intended for test and development purposes inasmuch as further development, possibly for improvement or refinement, apparently is being continued.

There appears to be little activity in the field of coaxial cable development at the present time. Most Bloc countries have completed development or have had access to completed studies on the different types of coaxial cables and their relative merits. The limited use of coaxial cable for high-capacity transmission systems appears to result from a problem of production.

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* Although the designation K-600 has not been reported, it is believed that equipment for multiplexing 600 telephone channels will be developed.

** The PM-24 series includes three models, the A, C, and L.

*** There are 2 models of this equipment, the GTT/4000/500 for transmitting telephone and television signals and the GTT/4000/A for transmitting TV signals only.

Because of the inherent security against intercept and observation, once laid, a coaxial cable is difficult to locate. Unless mentioned in open literature during the planning or review stages, it is doubtful that details of cable installations will be disclosed to Western observers. The work on coaxial lines and allied equipment does not receive the fanfare given to achievements in other fields of communications improvement and development. The literature indicates that this work goes forward at a steady pace, while conflicting reports raise doubts as to the progress and quality of these programs. Most Bloc countries have completed development or have access to completed studies on the different types of coaxial cables and their relative merits.

III. Production

A. USSR

The USSR now produces microwave radio relay equipment for operation in the 2,000 mc/s and 4,000 mc/s regions and equipment for multiplexing 24, 30, and 60 telephone channels. With the exception of the export of a small number of sets to Bloc countries, the Soviet production of microwave radio relay equipment and the accompanying multiplexing equipment has been installed in domestic systems. Estimates of production of the Strela M and Strela T, the R-60/120, and Vesna equipment are shown below in Table 1.* These estimates reflect the starting dates of production and are based primarily on the estimated installation of equipment. They represent minimum production as they assume the operation of only one broadband channel for existing lines except where available information indicates otherwise.

Although direct information on the factory production of radio relay and multiplexing equipment in the USSR is practically non-existent, it has been possible to determine the year in which pieces of equipment went into production. The Strela M was first produced in 1955 at the test plant of the Scientific Research Institute of the Ministry of Communications and later was produced at one of the plants of the Ministry of the Radiotechnical Industry (MRTP). The Strela T, developed during 1955, was in production in 1956. The R-60/120 radio relay equipment was placed in production sometime in 1958. The first models of the Vesna equipment were produced at the Scientific Research Institute of the Ministry of Communications in 1957-58. The zero-series of the Vesna was produced in 1959 and the Vesna was believed to be in full series production by January 1960.

The USSR has not yet initiated the production of large quantities of high capacity multiplexing equipment. The KRR 30/60, which can be used in pairs for multiplexing up to 60 telephone channels, has been produced for several years. The K-60 multiplexer in 1959 was undergoing tests to eliminate operational defects. It is estimated that full production of the K-60 was started in 1960. Other multiplexing equipment for 300, 600, 900 and 1920 telephone channels probably will be placed in full production during 1961-65.

The relatively low level of Soviet production of the R-60/120 and Vesna radio relay equipment cannot be attributed to any particular production difficulties. The USSR has demonstrated the capability to produce critical components needed in microwave radio relay equipment such as traveling wave tubes, klystrons, metal-ceramic "lighthouse" triodes, and wave guides, although tube reliability and service life still present some problems. The USSR has not allocated production resources, however, to provide these components in quantities adequate for both military and civil needs. Therefore, the problem of the Ministry of Communications in obtaining adequate production of the Vesna and R-60/120 for installation on radio relay lines has been, in part, a problem of priorities for components with the military having first choice. Similarly, the matter of priorities has also affected adversely the procurement of adequate factory space for the series production of the Vesna.

Although coaxial cables with 1-, 2-, and 4-coaxial tubes are produced in the USSR, there is little data available to permit the quantification of this production. The USSR is known to have imported coaxial cable indicating that the capacity for production has not been adequate to satisfy domestic requirements.

B. East Germany

East Germany has been producing microwave radio relay equipment since 1950. The RVG-903, used for transmitting up to 24 telephone channels, has been produced since 1952. The production of television relay equipment was started in 1954 with the RVG 904 television video transmitter and the RVG 905 which relays the audio signal. Further improvements on the television relay equipment were completed by 1958 and the RVG 908 video relay system went

* Table 1 follows on p. 4 .

Table 1

Estimated Production of Microwave Radio Relay Equipment,

Soviet Bloc, 1952-1965

	Units*							
	1952-55	1956	1957	1958	1959	1960	1961**	1962-65**
USSR								
Strela M	10	20	50	50	50	50	50	100
Strela T	0	10	30	30	40	40	40	60
R-60/120	0	0	10	25	40	50	50	200
R-600, Vesna	0	0	5	10	30	50	100	800-1,250
EAST GERMANY								
RVG-903	200	100	50	50	20	20	0	0
RVG-904	40-60	30	20	0	0	0	0	0
RVG-905	40-60	30	20	0	0	0	0	0
RVG-908	0	0	0	15	20	40	40	5
RVG-955	0	0	0	15	30	40	40	15
RVG-934	0	0	0	0	20	50	50	100
RVG-935	0	0	0	0	0	0	0	120-170
RVG-958	0	0	0	0	0	0	0	150-200
HUNGARY								
PM-24	0	0	10-20	40	125-150	125-150	50-75	0
PM-28	0	0	0	0	0	10	50-75	300
GTT/4000	0	0	0	0	0	0	25-50	300-400

* A unit of microwave radio relay equipment is considered to be one transmitter and one receiver for initiating, relaying, or receiving one radio frequency channel in one direction.

** Estimates of production for 1961-65 are extremely tenuous, having as their principal base rough estimates of facilities to be installed during the period.

into series production along with the audio relay equipment, RVG-955. No new 24-channel microwave radio relay equipment was brought into production by East Germany, however, until 1959 when the RVG-934, designed for pulse position modulation, finally reached the production stage. The RVG-935, a 28-channel partly transistorized set, is to replace the RVG-934 in production in 1963. It is estimated that the East German RVG-958, 600-channel equipment comparable to the Soviet Vesna also will be in production in 1963. Table 1 shows the estimated production of microwave radio relay equipment in East Germany.

The production of East German radio relay equipment was until about 1955 largely for export to the USSR and other bloc countries. Since that time, however, export markets for East German equipment have fallen away and the industry has concentrated on production of equipment for use in domestic systems. Such is still the case today, and proposed East German communications systems apparently will consume most of the country's production at least through 1965.

East Germany has not yet introduced into production the V-60 multiplexing equipment. A limited number of experimental units were produced at the VEB Fernmeldewerk Bautzen. The operating quality of the equipment, however, was so low that the end users would not accept the equipment without further development. ~~It is estimated that~~ Production of the V-60 will be ~~was~~ new initiated in 1961, but the equipment has not been entirely satisfactory mainly because of unreliable components.

In East Germany the production of radio relay and multiplexing equipment for high capacity systems has been delayed primarily by problems of development. The repeated loss by defection to the West of experienced scientists and technicians responsible for the development of radio relay and multiplexing equipment has set back the planned production of the RVG-934 and 958 and the V-60 from one to three years. Similarly, the defection of technically qualified personnel also has adversely affected the development and production of microwave tubes and other components so that the problem of adequate supplies of these components may become a deterrent to series production when development has been completed.

East Germany produced coaxial cable until about 1957, when, because of the high cost of manufacturing, this production was discontinued. The installation of new machinery at the KWO (Kabelwerk Oberspree) probably will enable East Germany to start the production of this 4-tube coaxial cable by 1962. A styroflex coaxial cable, type 17a, having one coaxial tube and 16 balanced pairs, is being produced presently in East Germany.

C. Hungary

Hungary produces radio relay equipment primarily for export to other Sino-Soviet Bloc countries. The Hungarian 24-channel, 2,000 mc/s radio relay equipment, PM-24, has been in production since 1957. The PM-28 was first produced in 1960, and the Hungarian GTT/4000 probably will be produced in 1961. Estimates of the production of this radio relay equipment are shown on Table 1, above.

Delays in production of 4,000 mc/s radio relay equipment in Hungary cannot be attributed to manufacturing difficulties. In Hungary, as in East Germany, the production of the GTT/4000 equipment has been delayed primarily by development problems. Hungary has had long experience in the production of telecommunications equipment and in the production of electron tubes. This, plus the fact that production facilities at the Beloiannisz Plant are being expanded, should expedite the production of high capacity radio relay equipment when development has been completed.

D. Czechoslovakia

Microwave radio relay equipment for the transmission of television broadcasts is produced in Czechoslovakia. Very little is known, however, about the volume of this production. The Czech DF 11 television relay equipment operates at frequencies between 4,500 and 5,000 mc/s. The MR 12 portable directional transmitter operates at frequencies up to 9,000 mc/s. Both of these equipments were being tested in 1959, and they are to be used only for

short television relay lines within Czechoslovakia. It is estimated, therefore, that production of the RF 11 and the MR 12 will be limited to a small number of units. Main telecommunications lines within Czechoslovakia will be equipped with imported radio relay equipment.

B. Poland

The Polish electronics industry has not indicated a capability for developing high capacity microwave radio relay equipment. It is possible, however, that copies of the Vesna were assembled in Poland in 1960. Poland has initiated the production of 4-tube coaxial cable at the Krakow Cable Factory, and will likely produce cable for other Bloc countries. Information does not permit the quantification of Polish production of coaxial cable.

IV. Operational Facilities

At the present time the Soviet Bloc is just beginning to establish a modern mainline multi-purpose/multi-user telecommunications network. The need for such facilities has been recognized by the Bloc for a number of years and was reflected in announced Soviet plans as early as 1956. Since that time, however, progress on the establishment of this network apparently has been slow.

The two avowed purposes of this modern mainline telecommunications network are to increase interurban and international telephone service capacity and to establish a Bloc-wide television network. Although television network service has been given the most publicity, it is believed that the strategic implications of expanded mainline telecommunications facilities may be the primary motivating force. Plans call for the use of both microwave radio relay and coaxial cable facilities in this network. In some instances it is believed that microwave and cable lines will more or less parallel each other. The use of both microwave and cable facilities not only provides a large service volume potential, but also reduces substantially the overall vulnerability of the network. Cable lines can be "hardened" by burying both the cable and repeater stations, thus reducing vulnerability to disruption from air attack or other causes. Microwave lines, because of the spatial separation of the stations (25-34 miles), can be easily guarded, thus reducing vulnerability to sabotage. The dual use of these facilities even on the same route, therefore, offers advantages that may well justify the added cost involved.

A. USSR

The Seven Year Plan of the USSR calls for the establishment of an estimated 30,500 km. of main telecommunications lines by the end of 1965. These lines are to provide domestic and international television network service and interurban and international telephone service. As the facilities to be installed are multi-purpose/multi-user and as they will provide the backbone of the mainline telecommunications network in the USSR, both civil and military will share their use.

Progress in fulfilling the Seven Year Plan for main telecommunications lines in the USSR appears slow. These lines utilize both microwave radio relay and coaxial cable facilities. Table 2* summarizes the various types of equipment employed on these lines and indicates equipment capacity potentials, lengths of line on which the equipment is employed, and present service usage.

As can be seen from the table, the majority of microwave lines in operation at the present time in the USSR utilize Strela M or Strela T equipments and only a very few lines employ R-60/120 or R-600 (Vesna) microwave or coaxial cable facilities. In addition, the majority of the higher-capacity lines are not being utilized at anywhere near designed capacity potentials.

* Table 2 follows on p. 7 .

Table 2

Estimated Microwave Radio Relay and Coaxial Cable in the USSR

Equipment	Capacity					Estimated Length of Lines (km)	
	Pass Band a/	Telephone Channels		Television Channels			
	mc/s	Design Potential	In Use	Design Potential	In Use	In Operation End of 1960	Planned Total End of 1965
Microwave Radio Relay b/						10,200	27,500 d/
Strela M	6 (600)	24	24 c/	0	0	5,000	7.000
Strela T	12	0	0	1 e/	1	3,000	5,000
R-60/120 (Strela P)	20 (2000)	120	Unknown f/	1 g/	1	700	
R-600 (Vesna)	33 (3300)						15,500
Phase I h/		1,200	0	1 i/	1	1,500	
Phase II		1,800	-	2	-		
Phase III		3,840	-	3	-		
Coaxial Cable		1,920	Unknown j/	2 i/	1	900 k/	3,000

a. Pass band is that band of frequencies passed with little or no attenuation. To allow for deviation and stability of carrier frequencies only 1/3 to 1/2 of the pass band may be used for communication. Figures in parentheses are an approximation of the maximum channels per rf band.
b. Only Soviet equipment is cited here, although equipment from other Bloc countries also will be used.
c. Some lines carry audio for Strela T television transmissions and radiobroadcasting programs.
d. Announced total of 27,500 km. remaining microwave breakdowns are estimated.
e. Video only, audio carried by Strela M, one reversible television channel.
f. An indeterminate number of telephone channels may be in use on some of these lines.
g. One reversible television channel.
h. According to Soviet literature, the capacity of R-600 equipment will progress in three phases. Presently operating lines, however, are not operating up to Phase I requirements as no telephone service has as yet been determined.
i. Simultaneous two-way television channel.
j. Vestnik Svyazi No. 10, 1960 states that K-1920 multiplexer has appeared on cable mainlines. This does not indicate definitely, however, the number of channels in use.
k. An additional 850 km. of line is under construction (Moscow-Helsinki via Leningrad and Viipuri).

Twenty-four telephone channel multiplexing equipment (K-24) is the highest capacity equipment presently in use on microwave radio relay lines. Multiplexing equipment KFR 30/60 and K-60 are in use on multiconductor cable lines in the USSR. The K-1920 multiplexing equipment also has appeared on Soviet cable mainlines according to a report in Vestnik Svyazi.*

A comparison of planned goals and present status, both in terms of length of lines and capacity exploitation, casts serious doubts at this time on plan fulfillment. It is possible that the majority of lines planned are not to be completed until the latter part of the plan period, perhaps in 1964 and 1965. This may also be true for capacity utilization. Announcements by the Ministry of Communications complaining about the slow progress being made and stressing the importance of network television expansion and the expansion of automatic interurban telephone service, however, tend to diminish these possibilities and to reinforce the suspicion that problem areas have developed.

IV. European Satellites

At the present time, there are no microwave radio relay lines in operation in the European Satellites that are comparable to the R-600 (Vesna) equipment in the USSR. There were some 6,000 km. of radio relay line in operation at the end of 1958, however, using many types of equipment that provide up to 24 telephone channels or one television channel. Table 3** summarizes the kinds of equipment in use in the European Satellites.

As pointed out above, both East Germany and Hungary are trying to develop Vesna-type equipment. Neither of these, however, are ready for operational use and the precise date for their introduction into use cannot be estimated. It is believed, however, that the GTT/4000 is in a more advanced stage of development than the RVG-958 and may be the first to become operational. It is probable that some of the 16,000 km. of line planned to be operational by at least 1965 will use RVG-958 and GTT/4000 equipments. In addition to the use of RVG-958 and GTT/4000 equipment, the R-600 may also be used in the European Satellites.

No coaxial cable routes are known to be in operation in the European Satellites at the present time although plans call for coaxial cable lines connecting East Germany, Czechoslovakia, Poland, and the USSR by the end of 1962. Implementation of plans to install such cable will be dependent on availability of 4-tube cable from the USSR Poland, or East Germany. Some type 17a coaxial cables have been layed in recent years, in East Germany, although these cables are reported to be inoperative because of a lack of 60-channel telephone multiplexing equipment.

The intra-Bloc television network (Intervision), which is scheduled to connect all Soviet Bloc capitals by the end of 1962, will use both microwave and coaxial cable facilities. In the early stages, R-600 probably will be the principal microwave equipment used, but as RVG-958 and GTT/4000 become available they also will be employed.

V. Problems

The apparently slow progress being made in the installation and operation of modern mainline telecommunications facilities in the Soviet Bloc has two facets: slowness in establishing new lines, and slowness in utilizing established lines at or near design capacity levels. The following are possible reasons for this slowness:

A. USSR

1. There has been a lack of allocation of resources for research and development and production of high-capacity microwave and multiplexing

* Vestnik Svyazi, October 1960, printed an article stating that K-1920 system has appeared on cable mainlines. This report has not been verified yet by other sources.

** Table 3 follows on p. 9 .

[redacted]

Table 3

Microwave Radio Relay Equipment in Use in European Satellites, 1960

Country and Equipment	Channel Capacity
Bulgaria	
RVG-934	24 telephone
Czechoslovakia	
DT-11	1 television
East German and USSR equipment	1 television
PFM-24 (Swiss and UK)	24 telephone
TR-1000 (French)	48 telephone
TM-110 (French)	1 television
East Germany	
RVG-903	24 telephone
RVG-904	1 television
RVG-905	1 radiobroadcast
RVG-908	1 television
RVG-934	24 telephone
KTR-1,000 and KTR-100 (UK)	1 television
Hungary	
PM-24	24 telephone
PM-28	24 telephone
IM-23 (Swiss)	24 telephone
Swiss and West German equipment	1 television
Poland	
RVG-903	24 telephone
PFM-24/2200 (West German)	24 telephone
TM-770 (French)	1 television
FHT-4003 (French)	1 television
Rumania	
RVG-903	24 telephone

[redacted]

equipment because of priorities imposed by Soviet military needs for other types of electronic equipment.

2. There has been indecision in allocating research and development and production facilities among alternative systems: microwave, coaxial cable, radio scatter, and possibly even long-distance waveguide.

3. The Soviets are proceeding slowly with installation in the early stages of the Seven Year Plan period with the intent of accelerating this installation in the latter stages of the plan when military demands for electronic equipment may be proportionately less.

B. European Satellites

The only known high-capacity microwave systems being developed in the European Satellites are the RVG-958 in East Germany and the GTT/4000 in Hungary. In East Germany, the RVG-958 is still in research and development because of lack of skilled labor and resource allocations. Information on the status of development of the GTT/4000 in Hungary is limited, but research and development difficulties possibly are being encountered.

VI. Major Gaps in Information

A. The status of the GTT/4000 in Hungary.

B. Production schedules for microwave radio relay equipment and coaxial cable in the USSR.

C. Status of multiplexing equipment development, production, and use of 60 telephone channels and above in the USSR, Hungary, and East Germany.

D. Yearly plan goals for installing microwave radio relay and coaxial cable lines in the USSR including proportions of various types of equipment to be used (plan data available covers only total plan goals for 1965 by major categories of equipment, i.e., microwave and coaxial cable).

E. Status of production of microwave radio relay equipment in Czechoslovakia.

VII. Major Research Gaps

A. An estimate of the total channel kilometers of microwave radio relay and coaxial cable facilities in the various countries of the Soviet Bloc. (Definition of channel kilometer needed.)

B. An estimate of the total number of microwave radio relay units in operation in the Soviet Bloc by type of facility. (Definition of unit needed.)

C. Refinement of the estimates of production and of facilities to be installed during 1961-65.